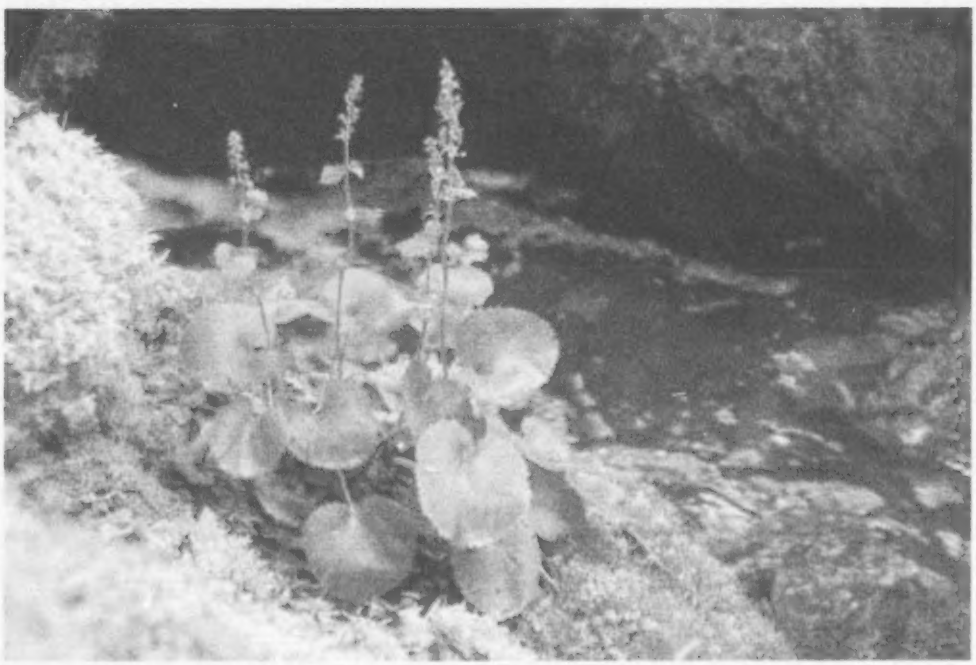
COSEWIC
Assessment and Status Report

on the

Spiked Saxifrage
Micranthes spicata

in Canada



THREATENED
2013

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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COSEWIC would like to acknowledge Rhonda Rosie for writing the status report on the Spiked Saxifrage, *Micranthes spicata*, prepared under contract with Environment Canada. This report was overseen and edited by Bruce Bennett, Co-chair of the COSEWIC Vascular Plants Specialist Subcommittee.

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Spiked Saxifrage — Photo: Syd Cannings, with permission.

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COSEWIC
Assessment Summary

Assessment Summary – May 2013

Common name
Spiked Saxifrage

Scientific name
Micranthes spicata

Status
Threatened

Reason for designation
This tall wildflower is one of a group of species found only in unglaciated areas of Yukon and Alaska. It lives along creek margins and is prone to the historical and current effects of habitat disturbance, such as placer mining. In addition, habitat is increasingly affected by natural disturbances such as flash flooding, forest fires, and landslides that may be increasing in frequency and severity due to climate change.

Occurrence
Yukon

Status history
Designated Threatened in May 2013.

COSEWIC
Executive Summary

Spiked Saxifrage
Micranthes spicata

Wildlife Species Description and Significance

Spiked Saxifrage is a large, showy perennial herb, growing singly or in tufts from short, thick rhizomes. The inflorescence is borne on a stalk 15-70 cm tall.

Spiked Saxifrage is an eastern Beringian endemic, one of a small group of species known globally only from unglaciated areas in Alaska and western Yukon. The six known Canadian sites are at the eastern edge of the species' range. In Yukon, Spiked Saxifrage appears to occupy a narrow ecological niche, with very specific habitat conditions and a short growing season.

Distribution

Spiked Saxifrage is endemic to Yukon and Alaska. In Alaska it occurs throughout much of the central part of the state; in Canada it is known from six creeks in the Klondike Plateau Ecoregion in western Yukon. Approximately 10% of its global range is in Canada. The combined area of occupancy (coverage on the ground) of all sites is <3 ha, or 0.03 sq. km.

Habitat

In Canada, Spiked Saxifrage grows on the banks and rocky shelves along creeks, on the moist ledges of adjacent outcrops, and on the narrow floodplain bordering the creeks. It grows in small piles of silt and moss-covered substrate, and on exposed soil near the creek. Plants may grow singly but often form dense clusters of up to several dozen plants. Alaskan populations of Spiked Saxifrage occupy a greater variety of habitats than do the Canadian populations found to date.

Creeks supporting populations of Spiked Saxifrage in Yukon share a number of characteristics: year-round flow of clear, cold water in narrow, rocky creeks that are subject to "glaciering" (i.e., *aufeis* ice that forms in winter as spring-fed water constantly flows over the frozen creek that may persist into July) or permafrost, which helps to maintain a humid, cold microclimate; with rock outcrops bordering the creeks, and abundant shade from forests of Alaska Paper Birch and/or White Spruce, alders and willows. One extant population has been heavily disturbed by placer mining, so its original condition is not known.

Biology

Little is known of the biology of Spiked Saxifrage. Reproduction is by seeds and by rhizomes; conditions for germination are unknown. Self-fertilization is common among Saxifragaceae and may occur with Spiked Saxifrage. Longevity of the plants and possible seed banks are unknown.

The plant's ability to withstand and repopulate after disturbance is unknown. It apparently can survive flooding, but severe flood events (e.g. a flash flood) may scour the floodplain and eliminate existing populations and possibly seed banks. However, plants growing on the outcrops above flood level may provide a seed source for repopulation, if essential habitat characteristics have not been altered.

Population Sizes and Trends

The six populations totalled 3678+ plants in 2012, with counts of 132, 1682, 6, 652, 502, and 700+ for individual populations. Approximately 2500 of the total are considered to be mature.

Despite over a century of botanical collecting in the region, Spiked Saxifrage was only reported once in Canada (in 1899) until it was rediscovered in 2009, so it seems the species was uncommon or rare even during the gold rush era of the late 1800s and early 1900s. Although no population trends can be derived directly from data at hand, much of the species' habitat was likely altered or destroyed by placer mining, road-building, and wood cutting since the late 1800s. These activities are continuing.

Threats and Limiting Factors

Placer mining is the most extensive and destructive human cause of habitat loss for Spiked Saxifrage in Yukon. Placer mining activity fluctuates in rate and scope as a as result of the changes in gold prices. Populations can be destroyed or diminished as a direct result of mining, or by upstream activities that affect its habitat, such as siltation (sediment build-up), damming, stream realignment, etc. As well, natural processes such as flash flooding, forest fires, and landslides may be increasing in frequency and severity due to human-induced climate change.

Protection, Status, and Ranks

Spiked Saxifrage has a NatureServe Global rank of G3G4 (Vulnerable to Probably Secure). Its National Rank in the U.S. is N3N4 (Vulnerable to Probably Secure), and in Canada is N2 (Imperilled). Its Subnational Rank in Alaska is S3S4 (Vulnerable to Probably Secure), and in Yukon is S2 (Imperilled). The National General Status ranks for Canada and Yukon are both May Be at Risk.

Spiked Saxifrage currently has no legal protection in Canada (as of April 2013), and is not listed under the U.S. *Endangered Species Act* or the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES).

Active placer and/or quartz mining claims occur on or upstream of the plant's habitat on five of the six creeks. While there are restrictions on how operations are conducted on those claims, these are mainly for the protection of fish habitat, and there is no legal obligation to protect the habitat or existing populations of Spiked Saxifrage.

TECHNICAL SUMMARY

Micranthes spicata
Spiked Saxifrage Saxifrage à épis
Range of occurrence in Canada (province/territory/ocean): Yukon Territory

Demographic Information

Generation time: *unknown, but the plants are perennial and likely do not flower for a few years after establishment. The cool shaded habitat and short growing season may suggest individual plants are very long-lived.*	3+ years
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals*? Inferred decline based on continued habitat loss and degradation.*	Yes, inferred
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	No
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence	7213 km²
Index of area of occupancy (IAO)	24 km²
Is the total population severely fragmented? *>50% of the population is in patches that are large enough to be considered viable.*	no
Number of locations	6
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	No
Is there an inferred continuing decline in index of area of occupancy?	Unknown, but likely
Is there an inferred continuing decline in number of populations?	Yes
Is there an inferred continuing decline in number of locations*?	Yes
Is there an observed continuing decline in area, extent and/quality of habitat?	Yes
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations*?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	N Mature Individuals (total individuals)
Donahue Creek	57-132 (132 total)
Spicata Creek	1054 (1682 total)
Fourth Creek	1 (6 total)

Snow Creek	~492 (652 total)
Dry Creek	352 (502 total)
Sanpete Creek	~525+ (700+ total)
Total (3678+ is the total number of rosettes)	2481-2556+

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	not done

Threats (actual or imminent, to populations or habitats)

Present and future placer and quartz (hard rock) mining and associated human disturbance; natural and human-caused wildfire; landslides and floods associated with extreme weather events and fire; climate change causing increase in wildfire and extreme weather events.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? Alaska S3S4 (vulnerable to apparently secure)	
Is immigration known or possible?	No
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada? *Habitat loss is considered a key threat.*	Yes
Is rescue from outside populations likely?	No

Status History

Designated Threatened in May 2013.

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Threatened	B1ab(iii)+2ab(iii)

Reasons for designation:

This tall wildflower is one of a group of species found only in unglaciated areas of Yukon and Alaska. It lives along creek margins and is prone to the historical and current effects of habitat disturbance, such as placer mining. In addition, habitat is increasingly affected by natural disturbances such as flash flooding, forest fires, and landslides that may be increasing in frequency and severity due to climate change.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not met, trend data not available.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Threatened B1ab(iii)+2ab(iii) as EO <20,000 km² (7213 km²) and IAO <2000 km² (24 km²), is known to exist at fewer than 10 locations and there is a continuing decline in the extent and quality of habitat.
Criterion C (Small and Declining Number of Mature Individuals): Not met but comes close to meeting Threatened C2a(i) as one population has 1054 mature individuals, all others are under threshold. However, there is insufficient evidence to support continuing decline of mature individuals.
Criterion D (Very Small or Restricted Total Population): Comes close to meeting Threatened D2 with only 6 known locations, small IAO (24 km^2), and is subject to human activities (mine development) or stochastic events (flash floods, forest fires, and landslides that may be increasing in frequency and severity due to human-induced climate change.
Criterion E (Quantitative Analysis): Not done.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2013)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

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Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

on the

Spiked Saxifrage

Micranthes spicata

in Canada

2013

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Scientific name: *Micranthes spicata* (D. Don) Small

Synonyms: *Saxifraga spicata* D. Don
Saxifraga galacifolia Small
Micranthes galacifolia (Small) Small

English common name: Spiked Saxifrage

French common name: Saxifrage en épi

Family: Saxifragaceae, Saxifrage Family

Major plant group: Angiosperm - Eudicot flowering plant

The family Saxifragaceae has undergone considerable revision in the past several decades, resulting in the splitting of the genus *Saxifraga* into *Saxifraga* and *Micranthes*, based on molecular phytogenetic data (Wells and Elvander 2009). Spiked Saxifrage is the largest of the ten species of *Micranthes* in Yukon, and of the 20 species that occur in Alaska and northwestern Canada (Brouillet and Elvander 2009). No subspecies or varieties of *Micranthes spicata* have been described.

Spiked Saxifrage was first collected in 1822 on Sledge Island on the Seward Peninsula of Alaska by David Nelson, a botanist on Captain Cook's third voyage, and was later described by David Don as *Saxifraga spicata* (Bennett and Withers 2010). The first specimens from Canada were collected in 1899, and were described as a new species, *S. galacifolia* Small (Britton and Rydberg 1901). However, Eric Hultén considered *S. galacifolia* synonymous with *S. spicata* (Hultén 1941).

Morphological Description

Spiked Saxifrage (Figure 1) is a showy perennial herb, growing singly or in tufts from short, thick rhizomes. Leaves are mainly basal, with long-petioles, orbicular to reniform (kidney-shaped) leaves covered with fine short hair or becoming hairless with age, and with sharply toothed and ciliate margins. Stem leaves, if present, are small, ovate to linear, and lack petioles. The inflorescence is borne on a stalk 15-70 cm tall, forming slender, compact, glandular-pubescent panicles. Fruits are basally connate, green and purplish-tinged capsules, 5-8 mm long. Seeds are small, brown, and longitudinally ribbed (Brouillet and Elvander 2009).

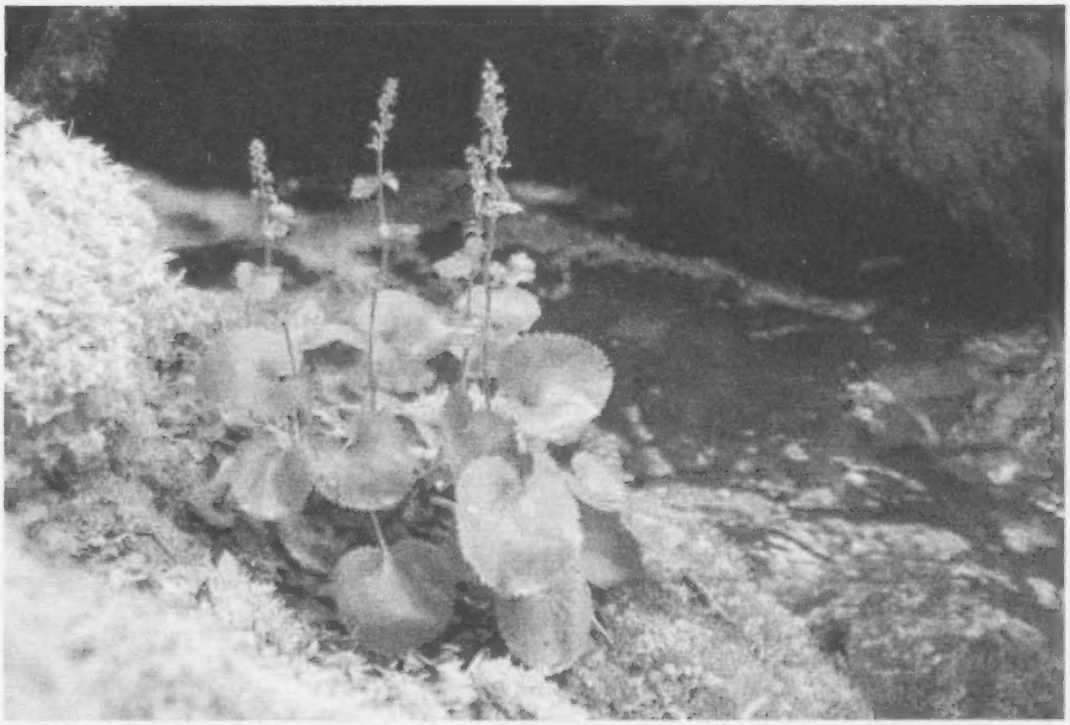

Figure 1. Spiked Saxifrage in fruit, Spicata Creek, August 25, 2010 (Photo: Syd Cannings).

The plant somewhat resembles Heart-leaved Saxifrage (*Micranthes nelsoniana*), which occurs in similar habitats but is overall a smaller plant than Spiked Saxifrage. Both species have round, orbicular leaves, but those of Spiked Saxifrage have more numerous teeth relative to *M. nelsoniana*. Flowers of *M. nelsoniana* have white petals 2.5-4.5 mm long, and form congested capitate or corymb-like panicles with 10+ flowers, and capsules that are 3-6 mm long, while those of Spiked Saxifrage have cream to yellowish petals 4-7 mm long, forming spikes of 15+ flowers, with capsules 5-8 mm long.

Population Spatial Structure and Variability

Six isolated populations of Spiked Saxifrage are known from Yukon, along four tributaries of the Yukon River, and two tributaries of the White River which is a major tributary of the Yukon River. While it is possible that some genetic differentiation exists in these isolated populations of Spiked Saxifrage at the eastern edge of its overall range, no investigations have been undertaken to determine this.

Designatable Units

Because all six known populations occur in the same COSEWIC ecological zone (Northern Mountain), and because there are no known genetic differences among populations, only one designatable unit is recognized.

Special Significance

Spiked Saxifrage is significant in being an eastern Beringian endemic, one of a small group of species known globally only from unglaciated areas in Alaska and west-central Yukon (Klondike Plateau Ecoregion).

The plant in Yukon seems to occupy a narrow ecological niche, with very specific habitat conditions. Thus far it has been found only in the riparian zone and on adjacent rock outcrops along rocky, shaded creeks having a cold, humid microclimate and a short growing season.

No traditional uses of the plant have been reported by the Tr'ondëk Hwëch'in First Nation in the Yukon range of Spiked Saxifrage (Olson pers. comm. 2011), but in Alaska the plant has been used as food by Alaskan Aboriginal peoples (Moerman 1998).

DISTRIBUTION

Global Range

Spiked Saxifrage has been found only in Alaska and western Yukon Territory. In Alaska, it occurs scattered throughout much of the central part of the state from the Yukon border to the west coast (Figure 2).

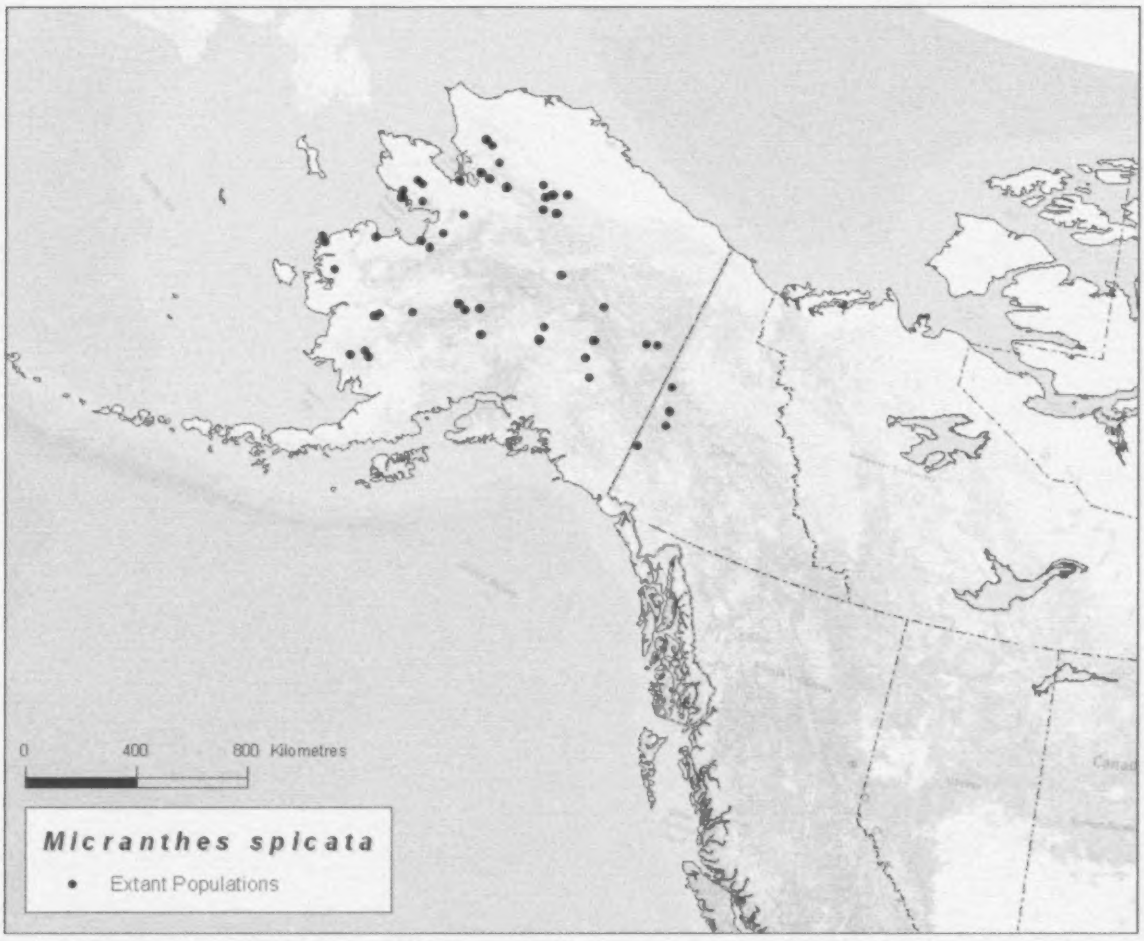

Figure 2. Global range of Spiked Saxifrage (Map Jenny Wu).

Canadian Range

Spiked Saxifrage is known in Canada only from six small creeks in the Klondike Plateau Ecoregion in western Yukon (Figure 3).

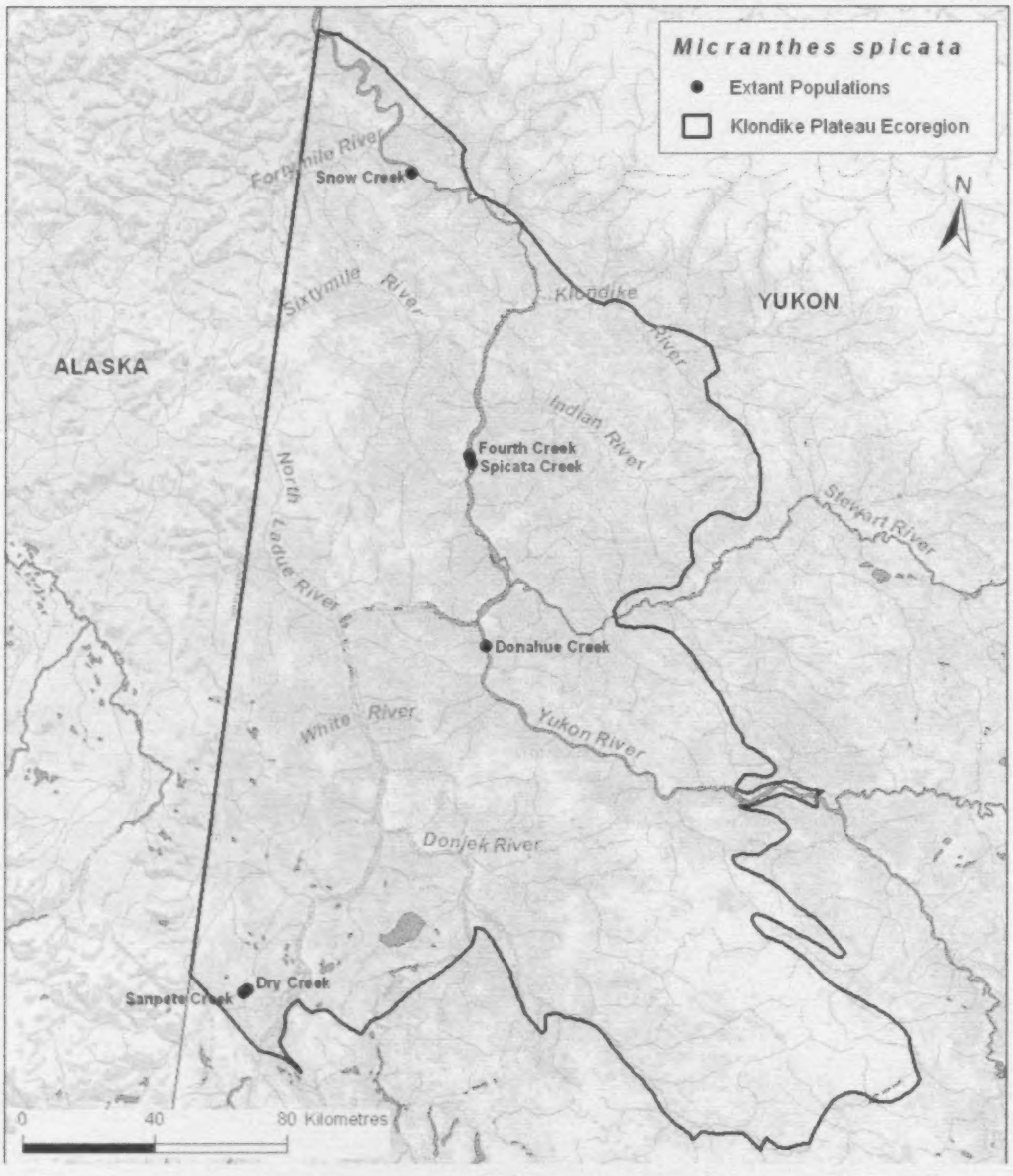

Figure 3. Potential Canadian range of Spiked Saxifrage showing the extant populations and the Klondike Plateau Ecoregion. (Map: Jenny Wu).

Four of the creeks are tributaries to the Yukon River: Donahue Creek (the gazetted name is Donohue Creek, but local and government usage today is Donahue Creek (Yukon Tourism and Culture March 2011)), "Snow Creek" (ungazetted), "Spicata Creek" (ungazetted), and an unnamed creek which will be referred to as "Fourth Creek" in this report. Two other creeks are tributaries to the White River, itself a main tributary to the Yukon River: Dry Creek, and the northernmost tributary of Sanpete Creek.

While there are thousands of creeks of all sizes in the Klondike Plateau Ecoregion, it is unlikely that very many of them host Spiked Saxifrage, either for natural reasons (i.e. the species' restricted/narrow ecological niche, poor dispersal abilities) or owing to human disturbance. Most of the 156 creeks checked recently (see Search Effort; Figure 5) along the Yukon River, Stewart River and upper White River had potentially suitable habitat, i.e., similar rich species diversity and physical attributes (Kennedy pers. comm. 2011), but only six (3.8% of those searched) contained Spiked Saxifrage.

The six Yukon streams occupied by Spiked Saxifrage possess similar physical characteristics, i.e., small narrow creeks, bordered by bedrock hills (Figure 4). In order to estimate how many populations of Spiked Saxifrage may theoretically exist in western Yukon, these physical characteristics were used in combination with aerial photos, satellite imagery, Google Earth images, and maps of bedrock outcroppings, to attempt to identify creeks in the Klondike Plateau Ecoregion with potentially suitable habitat for Spiked Saxifrage. A total of 211 creeks in ten drainages (including the Yukon River) met these rough criteria (Table 1). At an occupancy rate of 3.8% (based on results of existing search effort), extrapolation yields an estimated total of 8-9 possible sites for Spiked Saxifrage in Canada. However, placer mining (i.e. mining of alluvial sand and gravel deposits for minerals and gemstones) has occurred along many of these creeks and their tributaries, so it is likely that some existing or potential habitat for Spiked Saxifrage habitat has been degraded or destroyed.

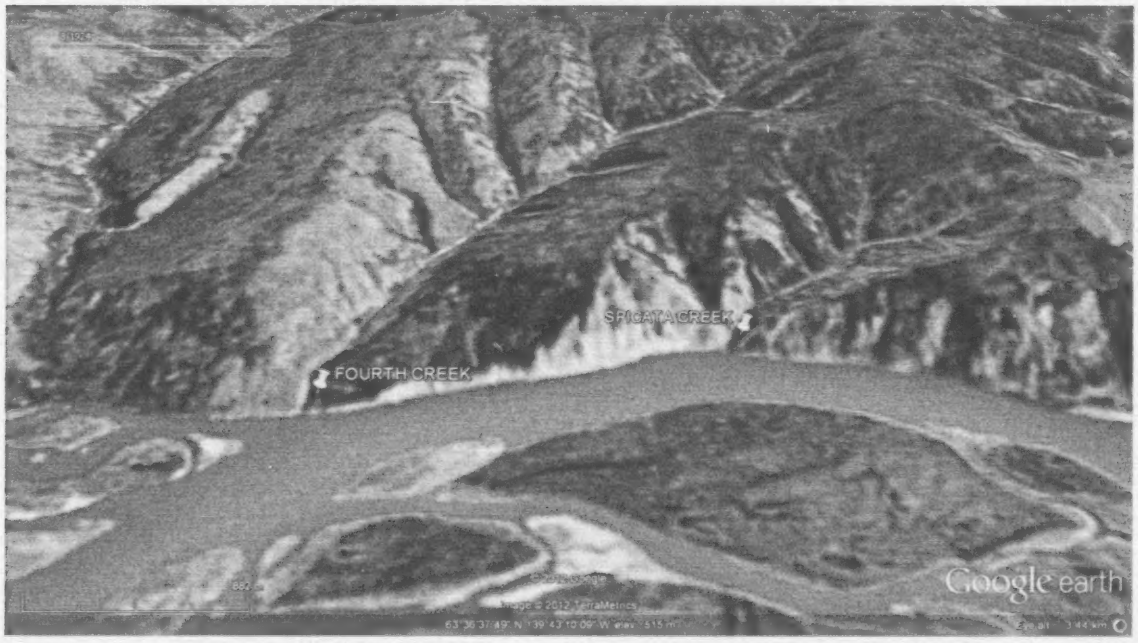

Figure 4. Google Earth image showing type of terrain where Spiked Saxifrage was found. Pins indicate approximate upper extent of known populations.

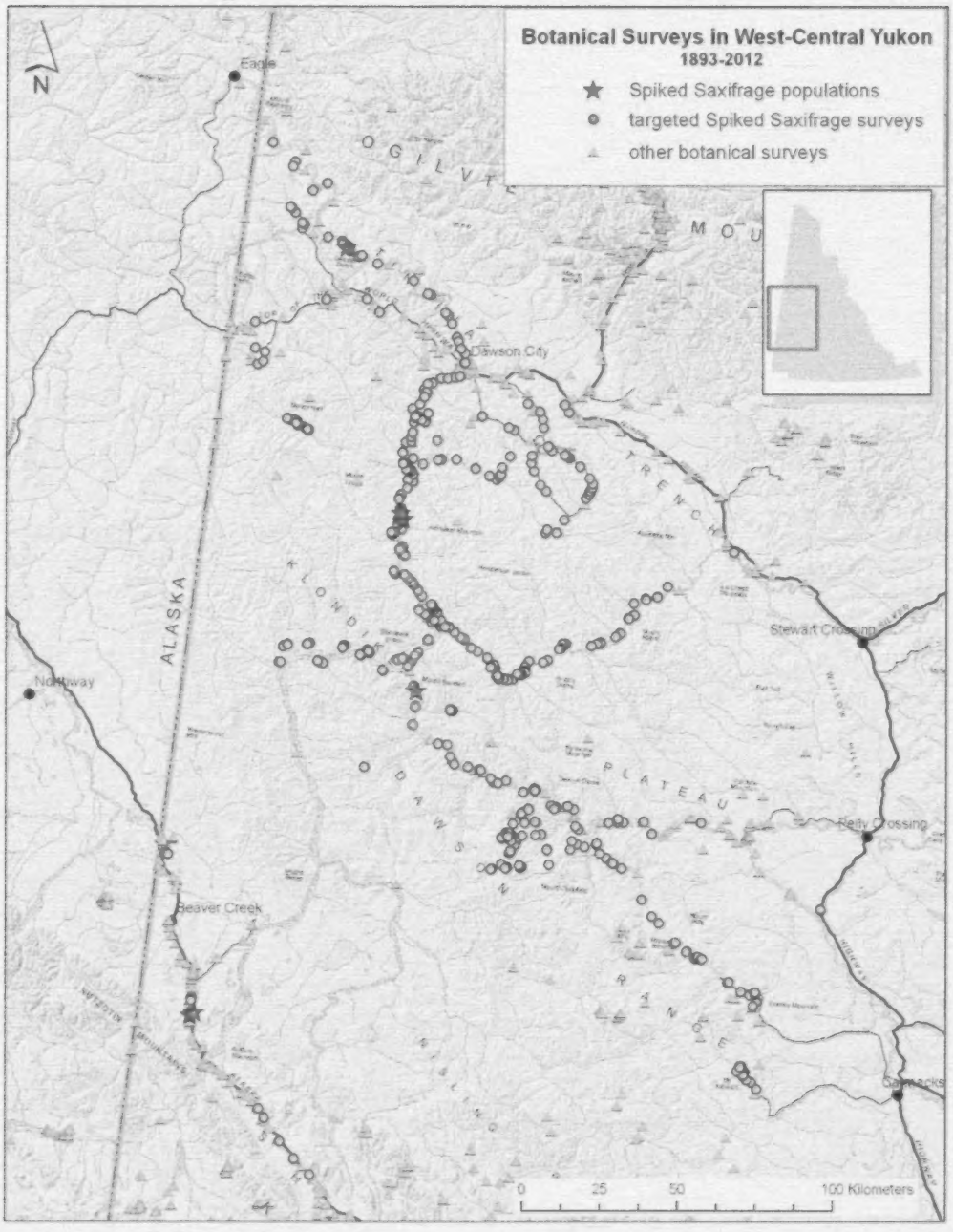

Figure 5. Spiked Saxifrage search effort along Yukon River and mining roads (Map: Randi Mulder).

Table 1. Rivers that may host Spiked Saxifrage.		
Drainage	**Total number of tributary streams (using 1 to 50000 map)**	**Estimate of possibly suitable creeks**
Yukon River	430	120
Stewart River	40	10
White River	150	25
Klondike River	54	5
Indian River	65	12
Sixty Mile River	103	15
Forty Mile River	18	8
Fifty Mile River	20	7
Donjek River	60	7
North Ladue River	60	2
TOTALS	**1000**	**211**

Extent of Occurrence and Area of Occupancy

The extent of occurrence (EO), based on a minimum convex polygon around known extant observations, is 7213 km². Using a 2 km x 2 km grid, the index of area of occupancy (IAO) is 24 km², and the actual area of occupancy is <3 ha, or 0.03 sq. km.

Search Effort

Spiked Saxifrage was first discovered in Yukon by the botanist John Berry Tarleton in 1899, during a canoe trip down the Yukon River from its headwaters to Dawson City (Tarleton 1900). He found it growing "along mountain streams" entering the Yukon River in the vicinity of the Indian River. According to his journal, this stream (or streams) was a short distance upriver of the Indian River; and is most likely Spicata Creek or Fourth Creek, which are immediately upriver of the Indian River (Bennett pers. comm. 2011; Cannings pers. comm. 2011).

Despite over a century of botanical collecting in the Territory since Tarleton's discovery in 1899 (Table 2), and repeated efforts to locate the plant (Bennett pers. comm. 2011), this large and conspicuous (tallest of the 10 *Micranthes* species found in Yukon) plant was not seen again in Yukon until 2009 at Donahue Creek (Bennett and Withers 2010).

Table 2. History of botanical exploration in Yukon River drainage (adapted from Hultén 1940 and Cody 1996).

Year(s)	Collector(s)	Affiliation	Locations
1883	Frederick Schwatka	United States Army	Yukon River
1887	George Mercer Dawson	Geological Survey of Canada	Pelly and Yukon river areas
1893-4	Frederick Funston	U.S. Department of Agriculture	Yukon River, Forty Mile Creek, Porcupine River
1898-9	Martin Woodlock Gorman		Yukon River between White Pass and Dawson Fort Selkirk, White River
1898-ca 1955	Martha Louise Black		Dawson area
1898-9	Robert Statham Williams	New York Botanical Garden	vicinity of Dawson, Klondike River
1898	Joseph Burr Tyrrell	Geological Survey of Canada	chiefly in the Dawson area, Forty Mile Creek
1898-1901	John J. McLean	U.S. Single Service	Dawson City and the Klondike Goldfields
1898-1900	Arthur L. Bolton		Dominion Creek, Fifty Mile River
1898	Frithiof Anderson	University of Gothenburg	Yukon River, Stewart River, Indian River, Dawson City
1898	Otto Nordenskjold	University of Gothenburg	Yukon River Stewart River, Eldorado Creek
1899	John Berry Tarleton		Yukon River to Dawson City
1899-1900	Wilfred H. Osgood	U.S. Biological Survey	Yukon River from source to Fort Yukon
1902	John Macoun	Geological Survey of Canada	in the Yukon Valley between Whitehorse and Dawson, Hunker Creek, Colorado Creek, Klondike River, Gold Run Creek, Klondike-Indian Divide
1903	Charles Arthur Hollick	New York Botanical Garden	Dawson
1905	E. Dossel		Yukon River
1909	Arthur Spear Hitchcock, Royal Shaw Kellogg	U.S. Department of Agriculture, U.S. National Forest Service	along the Yukon River between Whitehorse and Dawson
1908-1917	Donaldson Delorme Cairnes	Geological Survey of Canada	along the Alaska-Yukon border from 1908 to 1917
1914	Alice Eastwood	Herbarium of the California Academy of Science	the upper Yukon and Dawson areas, Moosehide, Dome Creek, Swede Creek, Bonanza Creek, Coffee Creek
1914	Margaret Milvain	Californian Academy of Science	Dawson and Glacier
1916	Oscar Malte	Curator National Herbarium, Ottawa	Yukon River valley and Dawson City
1918	W.E. Cockfield		Stewart River, McQueston Lake
1926-30	J.B. Mertie	U.S. Geological Survey	Tatonduk to Nation Rivers, Alaska Yukon border
1932	William Albert Setchell and Clara B. Setchell	Professors of Botany, University of California	Yukon River and Dawson City
1933	Isobel Wylie Hutchison		Yukon River and Dawson City
1933-1950	Hugh Bostock	Geological Survey of Canada	from the Mayo and McQuesten areas and Dawson Range
1936	R.V. Moran		Vicinity of Dawson
1949	James A. Calder	Canada Department of Agriculture	near Dawson
1984	William Cody, James Ginns	Agriculture Canada	Dawson and northern Dawson Range

Year(s)	Collector(s)	Affiliation	Locations
1990	Yukon Renewable Resources	Yukon Government	Vegetation survey, Dawson City east to Dempster Highway cutoff-100 plots
2001	Yukon Renewable Resources	Yukon Government	Vegetation and soil survey, eastern part of Klondike Plateau Ecoregion - 30 plots
2007	Environment Yukon	Yukon Government	Vegetation survey, along road west of Dawson and Top of the World Highway - 40 plots
2009	Environment Yukon	Yukon Government	Wetland survey, along Stewart River west to Yukon River - 31 plots (29 wetland, 2 grassland)
2010 and 2012	Rhonda Rosie	Western Copper and Gold Corporation	Rare plant survey south of Yukon River from west of Minto to Patton Hill

Following the rediscovery of the species at Donahue Creek, intensive targeted search efforts were made to locate more sites. From 2010 to 2012, a total of nine trips by Environment Canada, Canadian Wildlife Service (CWS) and Environment Yukon biologists, and two by the Tr'ondëk Hwech'in First Nation, were made by boat down the Yukon River to locate more creeks hosting Spiked Saxifrage. Five of the trips were along the Yukon River from its confluence with the Pelly River to Dawson City, two were from Dawson City to the Alaskan border, one searched the Stewart River, and two searched the area of the upper White River. A total of 142 creeks accessible from the Yukon and Stewart rivers were surveyed along both sides for at least their lower reaches (50 m), and those that appeared to have habitat potential for Spiked Saxifrage (i.e. rocky banks, and not obviously peaty or disturbed) were searched upstream from their mouths for 300 to 500 m. (Figure 5).

A road-accessed survey was also carried out in 2011 (Rosie 2011). Fifty-three creeks encountered during 7 days were checked for Spiked Saxifrage, and included headwater creeks accessed from roads along the ridges, as well as valley bottom creeks. However, many of the creeks have been affected by extensive human disturbance, and only a few streams were encountered that appeared relatively undisturbed with suitable habitat for the species. No Spiked Saxifrage populations were found during this survey.

In addition to the above searches, Dawson City botanists spent two days in July 2011 searching for Spiked Saxifrage in seven creeks (four along the lower reaches of the Indian River, and three along the Yukon River). They reported that most of the creek habitats appeared boggy ("muskeg trickles") and unsuited for Spiked Saxifrage, and no plants were found (Brunner pers. comm. 2011).

Reconnaissance-level rare plant surveys were carried out by Rhonda Rosie in 2010 and 2012 south of the Yukon River from west of Minto to Patton Hill, as part of environmental assessment surveys for mining projects. The survey included a wide variety of vegetation types from lowland to alpine, including a number of creeks. While Spiked Saxifrage was not the main focus of these surveys, it was not found in any habitats encountered (Rosie, unpubl. data).

Surveys along more than eight creeks on the lower reaches of the White River in suitable habitats were also done as part of another survey. While Spiked Saxifrage was not the main focus of these surveys, no Spiked Saxifrage was found (Dar pers. comm. 2012).

Finally, two trips were carried out in 2012 by the CWS along the Alaska Highway to survey the White River's headwater streams near the community of Beaver Creek. The first trip discovered Spiked Saxifrage in the upper reaches of Dry Creek. The second trip examined creeks from the Canada/USA border to the Donjek River and found a second population in an upper tributary of Sanpete Creek. Sanpete Creek is adjacent to Dry Creek and shares the same headwater drainage. Dry Creek and Sanpete Creek were searched below the populations but no additional plants were found. Areas upstream of the populations were searched to determine where the populations apparently ended; however, not all areas above (upstream) of the known populations have been searched.

In all cases, time and access constraints resulted in a) many creeks not being sampled because they appeared to have a low likelihood of supporting Spiked Saxifrage; b) some creeks not being sampled because access was difficult or time-consuming; and c) most creeks being sampled only to a point where it was judged that the habitat was not likely to support Spiked Saxifrage farther upstream.

HABITAT

Habitat Requirements

Alaskan populations of Spiked Saxifrage occupy a greater variety of habitats than do the Canadian populations found to date, based on over 60 specimen collections from about 40 sites, housed at the University of Alaska Museum of the North Herbarium (2009), in Fairbanks, Alaska. Most of the Alaskan specimens occur in areas with a cold, maritime climate where the common habitats for Spiked Saxifrage range from sea level to alpine, on tussocky tundra and wetlands, ledges and crevices of rock outcrops, on scree slopes and in boulder fields, turfy alpine and subalpine sites, and along creeks. In sites closer to the Alaskan coast presence of tussocks is commonly noted.

Habitat information for specimens of Spiked Saxifrage from the Alaskan interior was reviewed to extract habitat features for the plant in terrain and climatic conditions similar to the Klondike Plateau. Five collections exist in the Alaskan interior between the Yukon border and the 151st line of longitude, and an additional five collections from the Alaska Range in southern Alaska were assessed. Unfortunately, the habitat data on the UAM herbarium specimen sheets are often sketchy, and elevations are often missing. Collection site coordinates were input into Google Earth to get rough elevations and a better sense of the terrain and, where high-resolution imagery was available, habitat. However, most of the coordinates were too imprecise to be sure exactly where on the landscape the plants were found (judging from habitat discrepancies between the collection data and what is seen on the Google Earth imagery). However, based on the herbarium sheet data, the rough elevations, and visible features on Google Earth imagery, some conclusions and inferences were made.

In the mountainous Alaska Range in southern Alaska, only one high alpine site (1417 m on the herbarium sheet) for Spiked Saxifrage is recorded, on "scree slope, snow flush meadow, occasional on gravelly scree slope". It was also found in what appears to be a subalpine site at about 1008 m on another mountain, "confined to a limited area" in a boulder field. Two collections were made in the Toklat River valley, between 900-950 m, on a "wet hillside" and "growing in woods". Along the southern edge of the Alaska Range, it was found in an upland site at about 660 m, growing in "heath-moss" in a "boggy site".

In the Ray Mountains in interior Alaska, a collection was made at around 950 m in an alpine or subalpine "moist snowbed graminoid community". Three other sites in the Interior (Yukon Tanana Uplands) occur on riparian "wide graminoid meadows which are often flooded", in a "partially dried up stream bed running parallel to active channel of Coal Creek", and in a "moist, mossy draw, under willows, 1070-1220 m". The site closest to the Yukon border where Spiked Saxifrage has been found is along a small steep creek flowing into the Yukon River, very similar to sites where it has been found in Yukon.

From these data, it appears that moisture is a main criterion for Spiked Saxifrage habitat. This is an obvious feature along streams and on floodplains. High elevation snowbeds, scree slopes, and boulder fields are often sites of late snowmelt with moist substrates during the growing season. The boggy upland site on the south side of the Alaska Range may be influenced by the maritime climate of the Pacific Ocean and not representative of conditions normally encountered in the interior of Alaska and Yukon.

Thus it seems likely that Spiked Saxifrage habitat in Yukon is mainly to be found in the boreal ecozone, associated with creeks as described in this report. While there are some mountain ranges within the Klondike Plateau with alpine terrain, they are much less extensive than the Alaska Range, and lie in a drier climate. Hence, features such as late-lying snowbeds and moist boulder fields are less common and found mainly in the highest elevations.

In the eastern portion of its interior Alaskan range and into Canada, habitats include White Spruce (*Picea glauca*) and Alaska Paper Birch (*Betula neoalaskana* and/or *B. kenaica*) forests, under willows (*Salix* spp.) and alders (*Alnus* spp.). Spiked Saxifrage was found growing on the banks and rocky shelves along the creeks, on the narrow floodplain bordering the creeks, and on the moist ledges of adjacent outcrops. It was observed growing in small piles of silt and moss-covered substrate, and on exposed soil near the creek. Plants may grow singly but often form dense clusters of up to several dozen plants, for >400 m upstream of the creek mouth along the Yukon River, and in similar habitat in the upper reaches of Dry and Sanpete creeks.

Donahue, Snow, Dry, Sanpete, and Spicata creeks share a number of characteristics: year-round flow of clear, cold water in narrow, rocky, mainly V-shaped creek valleys subject to "glaciering" (i.e., *aufeis* – ice that forms in winter as spring-fed water constantly flows over the frozen creek) that may persist into July or permafrost, which helps to maintain a humid, cold microclimate; with rock outcrops bordering the creeks, and abundant shade from forests of Alaska Paper Birch and/or White Spruce, alders and willows. Other vegetation consists of a diverse assortment of lower shrubs, mosses, grasses, forbs, and abundant leaf litter. Small bare patches of soil and accumulations of coarse woody debris also occur along the creeks (Figure 6). The vegetation along the steep slopes bordering the creeks comprises upland forests typical of the area, as well as open grassland on dry south-facing slopes.

Fourth Creek has been disturbed by placer mining, so its original condition is not known.

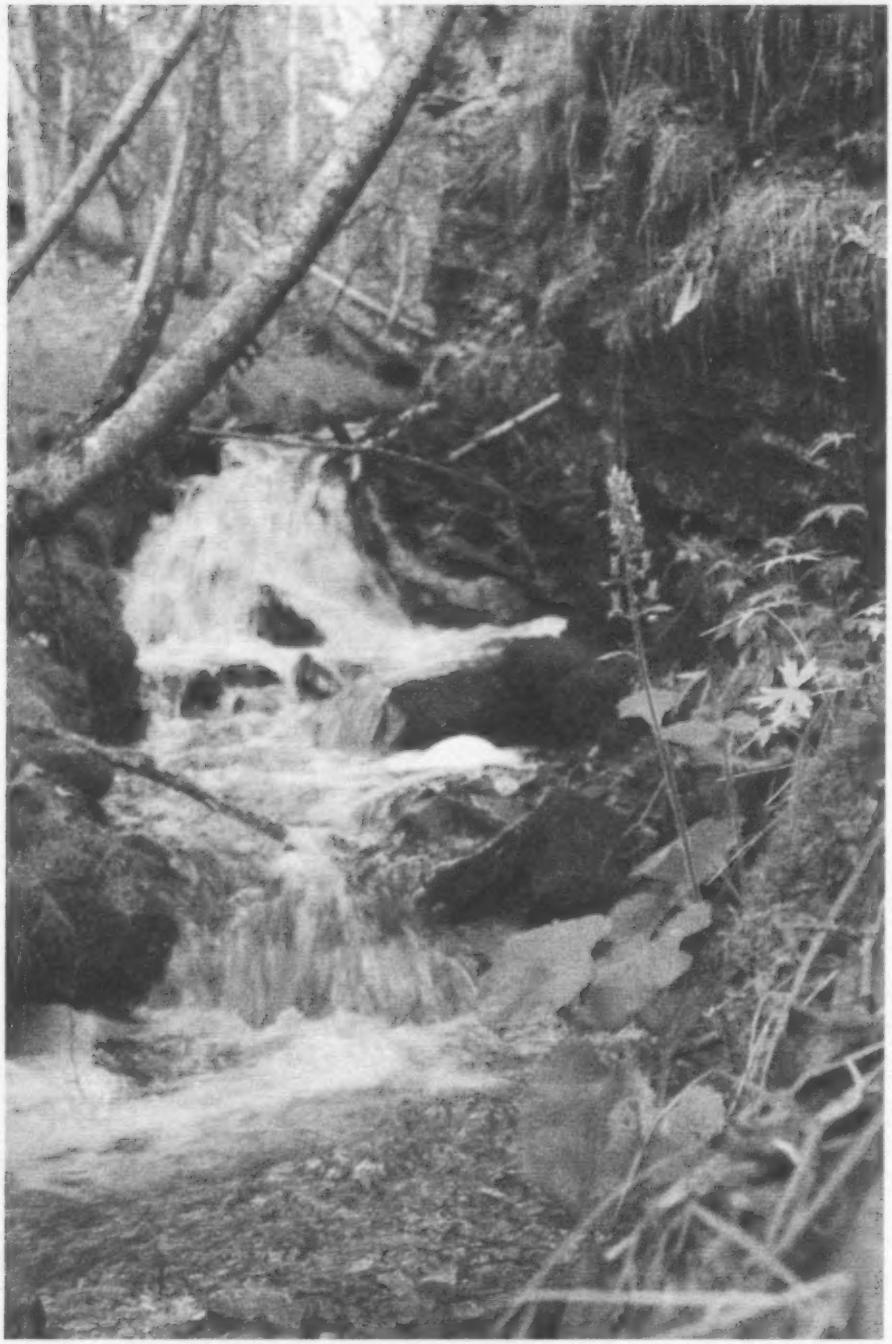

Figure 6. Spicata Creek, August 26, 2010 (notice capsules) (Photo: Syd Cannings).

Habitat Trends

Since the gold rush era of the late 1800s and early 1900s, the Klondike region has been heavily impacted by human activity (see also Threats and Limiting Factors). Placer mining is still actively being carried out along many creeks and rivers and, along with road-building, has greatly altered many drainages. The extensive quartz-mining claims (i.e. hard rock mining for gold associated with bedrock quartz veins) may also result in destructive changes to the landscape which are not confined to valleys. It is likely that much of the Canadian habitat of Spiked Saxifrage has been destroyed or degraded by placer mining during the Gold Rush era. Existing populations continue to be threatened by this activity.

There are six known extant sites for Spiked Saxifrage (Table 3). Donahue Creek is about 7.5 km long and about 5 m wide near its mouth, and flows through a relatively level rocky floodplain. Spiked Saxifrage plants were all found within 2 m of the creek edges (Cannings 2010). The creek shows evidence of old placer mining, but it appears the work was done by hand mining, and the creek may not have been redirected. One old placer pit at Donahue Creek occurs along the stream bank, and in 2011 Spiked Saxifrage was observed above and below the pit area but was noticeably absent along the banks at the pit. It is likely that the plant was present when mining began and although it probably declined during the mining, was able to persist in the drainage.

Table 3. Population Counts.

Creek	Date	Name of surveyors	Area of population *	Immature	Mature	Total count	Probable maximum totals	Comments
DONAHUE CREEK	11-Aug-10	Stu Withers	0.104108 ha	not recorded	not recorded	57, but count was incomplete	100-132	The 2010 count was incomplete. The 2011 count was intended to begin where the 2010 count left off, but there may have been some spatial overlap. Therefore, the total population is estimated at 100-132 individual plants. Plants grew on banks along creek.
	23-Jun-11	Saleem Dar		not recorded	not recorded	75, but count may include overlap from 2010		
SPICATA CREEK	26-Aug-10	Syd Cannings	0.717296 ha	200-300	200-300 (flowering)	>500	1682	The 2010 count was incomplete. The 2011 count covered the entire area of Spiked Saxifrage occurrence. *Aufeis* covered most of creek above the counted area. Plants grew along banks and on bordering cliffs.
	25-Jun-11	Saleem Dar		628	1054 includes plants without flower buds but which appear mature otherwise	1682		
FOURTH CREEK	25-Jun-11	Saleem Dar	too small to measure	?	?	1	1	Appears to be a survivor of former placer mining disturbance. Plant was growing on ground.
	21-July-12	Saleem Dar	2 clumps 20 m apart	5	1	6	6	500 m of creek was searched. The second plant was likely not detected the year before as it was not flowering.

Creek	Date	Name of surveyors	Area of population *	Immature	Mature	Total count	Probable maximum totals	Comments
SNOW CREEK	14-Sep-11	Saleem Dar and Sebastian Jones	0.044793 ha	not recorded	not recorded	>479; count doesn't include plants higher up on rock outcrop	>479	All occur on the rock ledges above the creek; none on ground along creek; plants senescing.
	19-Aug-12	Sebastian Jones		not recorded	not recorded	652	652	Numerous seedlings were counted as plants. This year the top of the cliff was skirted and the patch delineated better.
DRY CREEK	4-Sep-12	Saleem Dar Syd Cannings	0.604724 ha	150	352	502	502	Plants occurred in three patches. Reaches downstream of occurrence were searched without success.
SANPETE CREEK	11-Sep-12	Syd Cannings Shannon Stolyn Bruce Bennett	1.376125 ha	not recorded	not recorded	700	>700	Population seems to be restricted by available habitat. Upper reaches were not searched.
TOTALS			2.847046 ha				3642-3674	

* calculation courtesy of the Yukon Conservation Data Centre

Spicata Creek is much smaller than Donahue Creek, being about 2 km long and about 1-2 m wide near its mouth (Figure 6). It flows through a narrow, relatively steep gully, with many small rock cliffs on the south side of the creek. Spiked Saxifrage was observed growing mainly along the creek, but also on the floodplain up to 6 m away from the channel, as well as on the adjacent small north-facing cliffs. No sign of human activity in the area searched along the creek is apparent, except for a small pit in the rocky sediments at its mouth.

Fourth Creek is 2.5 km downstream of Spicata Creek and is about 5.8 km long. It has been severely disturbed by recent placer mining in its lower reaches, including torn-up earth and a human-constructed dam and pond. Floods, either natural or anthropogenic, have scoured the creek bed, and its edges appear "sheared off", with exposed roots and much less species diversity than the other three creeks (Kennedy pers. comm. 2011). In 2012, the creek was searched up to 500 m and two clumps of plants were found ~170 m upstream from its mouth. Each clump had three plants or ramets, and only one was flowering and therefore considered mature. One clump was growing on the stream bank about 1.5 m above the flooded area, and the second clump was growing immediately adjacent to the creek. These plants may have been part of a larger population that was eliminated directly or indirectly by placer mining (Dar pers. comm. 2012).

Snow Creek is about 5 km long, and flows through a steep, rocky valley. Spiked Saxifrage was found along the creek and on adjacent west-facing outcrops. There was no sign of human disturbance or recent flooding (Jones pers. comm. 2011).

Dry Creek and Sanpete Creek both drain the north and west slopes of several small hills, the tallest being Sanpete Hill at 1538 m (about 800 m above the White River). The upper reaches consist of steep (>30° slopes) and the lower reaches meander through Black Spruce (*Picea mariana*) peat bogs and sedge fens. Spiked Saxifrage was found in a section of the creeks reminiscent of the previously described sites, dominated by large old White Spruce, Alaskan Paper Birch, Felt-leaf Willow (*Salix alaxensis*), Speckled Alder (*Alnus incana*), with a rich understory of herbs and step-mosses (*Hylocomium splendens* and *Pleurozium schreberi* dominate). The creeks have good consistent water flow and drain cold permafrost-rich sites. Both sites are relatively intact, though a very old cabin exists at the lower end of Sanpete Creek.

BIOLOGY

Little is known of the biology of Spiked Saxifrage. The following information has been obtained from reports, observations, and Malcolm McGregor's book on saxifrages (McGregor 2008).

Life Cycle and Reproduction

Reproduction in Spiked Saxifrage is by seeds and by rhizomes. In 2012, Dar (pers. comm. 2012) observed "a very thick scaly rhizome that appeared to have multiple shoots arising from it" with "another ramet coming off the rhizome 4-7 cm from the main plant", and "some ramets appeared to come off of the rhizome even further away from the main plant (~ 15 cm)". Closer examination of the rhizomes at Sanpete Creek showed the presence of roots on the rhizome branches which suggest that if a crown was detached it could potentially survive independently.

Pollinators have not been identified, but likely include a variety of flies (muscids, syrphids, etc.; Carlson pers. comm. 2011). Dar (pers. comm. 2012) reported observing pollination by a syrphid fly (likely a species of *Melangyna*) and a bumblebee (probably *Bombus mixtus*) at Spicata Creek in 2012. Indirect and circumstantial evidence suggests that most species are wholly or partly self-compatible, and that a few are regularly self-fertilizing (although seed set may not be as abundant as when pollinated) (McGregor 2008). It is thought that Spiked Saxifrage is capable of self-fertilization.

Due to the distance between populations, it is unlikely that any pollen transfer occurs between them, except for perhaps Dry and Sanpete creeks.

Conditions for germination of this species are unknown, but McGregor (2008) says that in cultivation, germination of "most of the Alaska *Micranthes* tends to be difficult."

In early June, plants were just emerging and small basal leaves were present, but flowering stalks were small or absent (Cannings pers. comm. 2011). In late June, most, if not all, flowers were still in bud or flowering stalks had not yet emerged, and in late August many capsules were well-developed (Cannings 2010). Photos taken at Snow Creek on September 14, 2011, indicate that the plants were in senescence, with many leaves limp and browning, and many capsules fallen from the spikes (Jones 2011).

While Spiked Saxifrage is a perennial herb, the longevity of individual plants is unknown. Three years is a minimum estimate of age of maturity. The actual generation time may prove to be much greater. There is no information on the viability or longevity of seedbanks of this species. However, based on personal authoritative experience in growing Saxifragaceae (although not including Spiked Saxifrage), McGregor (McGregor pers. comm. 2012) speculates that "It would seem that a plant such as *M. spicata* probably lives for up to a decade at least." Regarding seedbank longevity of Spiked Saxifrage in the wild he believes that "Arctic seed may be long-lived in a seedbank since it is probably well-adapted to lengthy periods of freezing naturally".

Physiology and Adaptability

Spiked Saxifrage in Canada appears to be adapted to a narrow ecological niche characterized by a cold, humid microclimate, low light levels, a short growing season, and a variety of substrates (wet soil, rock crevices and ledges, woody debris).

Its ability to withstand and repopulate after disturbance is unknown. It apparently can survive at least some flooding (see also Threats), and the presence of rhizomes may aid the plant in surviving substrate disturbance.

Dispersal and Migration

Seed dispersal by Spiked Saxifrage is likely similar to other saxifrages, i.e. the seed falls from the capsules when ripe and stems are shaken by wind (Webb and Gornall 1989), and may be dispersed further by flowing water, humans, and other animals. However, the seeds have no apparent specialized adaptations to aid in dispersal (e.g. hooks, reticulations, pappus).

Interspecific Interactions

A caterpillar was observed feeding on Spiked Saxifrage leaves at Spicata Creek in 2012 (likely of the moth family Tortricidae; Dar pers. comm. 2012).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

As the locality of the first collection made by Tarleton was known to be along the Yukon River between the Sixty Mile and Indian rivers, initial surveys targeted habitats in this general region, expanding into additional drainages as the most likely habitats were eliminated.

Populations at the four creeks that are tributaries directly to the Yukon River were determined by counts of individual plants from the creek mouths to as far as 300-500 m upstream. Numbers of plants were highest in the lower 300 m of the creek, and none were found beyond 440 m upstream.

Population counts were made at Donahue, Fourth, and Spicata creeks in 2010 and 2011 (although counts in 2010 were rough estimates). Populations at Snow Creek were counted in 2011 when the plant was first discovered and again in 2012.

Populations at Sanpete and Dry creeks were discovered late in 2012 during targeted surveys to find Spiked Saxifrage. All plants were counted by walking in the creeks and tallying individuals along the banks. On Dry Creek flowering and non-flowering individuals were counted separately. On Sanpete Creek young plants may have been missed as late season frosts had caused wilting and collapse of many plants. Areas surrounding creeks were also searched including areas of apparently unsuitable habitat with no additional plants found. No plants were detected further downstream of those counted; however, the headwaters of the creeks have not been searched and may contain more plants.

Field measurements of the dimensions of the occupied areas were made using a GPS, as well as visual estimates.

Abundance

In 2010, the population at Donahue Creek was estimated at 57 mature individuals. A more extensive survey in 2011 resulted in an estimated total population of 100-132 plants. Maturity was not recorded.

In 2010, the population at Spicata Creek was estimated at >500 individuals, with 200-300 fruiting. In 2011, a more intensive survey resulted in a total count of 1682 plants, with 1054 mature and 628 immature.

In 2011, there was only one plant observed at Fourth Creek, and it was mature. In 2012, the creek was revisited and searched more thoroughly to 500 m. Two clumps of overlooked plants were found consisting of 6 individuals, one of which was mature (Dar pers. comm. 2012).

In 2011, the population at Snow Creek was estimated at >479 individuals, but it was not possible to reach all parts of the outcrop on which they grew for a complete count. As well, many plants were in advanced senescence and some may have been missed during the count. Maturity was not recorded. In 2012 a more complete count of the plants was done earlier in the season while plants were still in good condition. There were numerous seedlings included in the count. In total 652 plants were counted. In 2012, the top of the cliff was skirted and the population was delineated better.

In September 2012, two previously undetected populations were discovered on Dry Creek and Sanpete Creek – two creeks that share the same headwater slope. A total of 502 individual plants in three separate patches were counted on Dry Creek, of which 352 were flowering and considered mature. The population on Sanpete Creek consisted of a single continuous patch (largest breaks in the population were <10 m) that totalled 700 plants (actual count, not an estimate). However, this is considered to be a low estimate as the population was not completely delimited and due to the lateness of the season, many smaller immature plants may have been missed.

The total number of individual plants known in Canada as of 2012 is estimated at >3678 (Table 3) with mature individuals estimated to be approximately 2,500.

Fluctuations and Trends

Fluctuations of an order of magnitude are not known in populations of Saxifrages and are not expected to be occurring in Spiked Saxifrage. Population trends are also unknown.

While it is impossible to know how many populations of Spiked Saxifrage existed in the past, the species seems to have been uncommon or rare even during the gold rush around the turn of the 20th century, given that only one collection was made at that time. Martha Black, a resident of Dawson during and after the gold rush, made an extensive collection of plants of the region and did not report Spiked Saxifrage (Black 1940).

We can also infer that appropriate habitat (shady, cool, rocky creek banks) declined dramatically during the intense development that occurred in the area over the last 115 years. Most creeks in the broader Klondike region were at least tested for gold, and claims were registered on more than 400 creeks of all sizes (Yukon Archives 1989). Forests along the Yukon River were extensively and heavily logged for cabin and sluice box building, firewood, and fuelling river boats, and riparian forests in smaller valleys were "cut, burned, and consumed ... at an unprecedented rate" for building, heating, and for thawing permafrost in the gold-bearing gravels (Morse 2003). It thus seems likely that at least some (if not most) of the populations existing at the time of early European exploration and settlement would have been adversely affected, and potential future populations limited by lack of, or reduction/destruction of suitable habitat.

The absence of Spiked Saxifrage in the immediate vicinity of a hand-worked placer site along Donahue Creek indicates that the species was probably eliminated by the creekside disturbance and has not recolonized that reach of the creek.

While large-scale forest destruction for fuel and building no longer occurs in the Klondike region, modern mechanized placer mining is inherently destructive to creek valleys. There is still intensive placer mining and quartz exploration activity in the region today, and we can infer that remaining habitat for Spiked Saxifrage will continue to decline if mitigation measures are not implemented.

Rescue Effect

The nearest two known Alaskan populations of Spiked Saxifrage are 161 and 177 km (direct line) to the northwest of the closest population in Canada (Snow Creek). Repopulation from those sources is unlikely, as seed dispersal seems very unlikely to occur over such distances or against the current of the Yukon River.

THREATS AND LIMITING FACTORS

It appears that the greatest threats to Spiked Saxifrage are from both natural and human causes. Habitats and populations can be directly affected by mining activities, or indirectly through upstream natural or anthropogenic events such as flooding, landslides, siltation, damming, stream realignment, and any activities that affect the water flow.

As previously noted (Fluctuations and Trends), placer mining has very likely been the most extensive and destructive cause of habitat loss historically for Spiked Saxifrage, and this continues today. Placer gold is found in gravels along creeks and in the adjacent terraces and lower hill slopes. Placer mining has occurred in western Yukon from after the mid-1800s to the present, with especially intensive activity during the Klondike Gold Rush at the turn of the 20th century. Placer mining activity fluctuates in rate and scope as a result of the changes in gold prices. Exploration and staking recently have shown an increase in rate and scope as a result of the dramatic rise in the price of gold. With the recent discovery of large gold deposits in bedrock quartz veins in the Klondike region, vast areas have been staked for hard rock exploration and mining (Figures 7-8). Once-marginal placer operations are now lucrative propositions and creeks are being staked and worked or reworked. Exploration for hard rock ("quartz") mines in the region is occurring at a rate far above that seen in any previous year. In 2011 alone, 110,000 quartz claims (each 51 acres in size) were staked, almost double the last record set the year before. Though the majority of these will never be mined, there are now 250,000 such claims in Yukon, many of which are concentrated in the Klondike region.

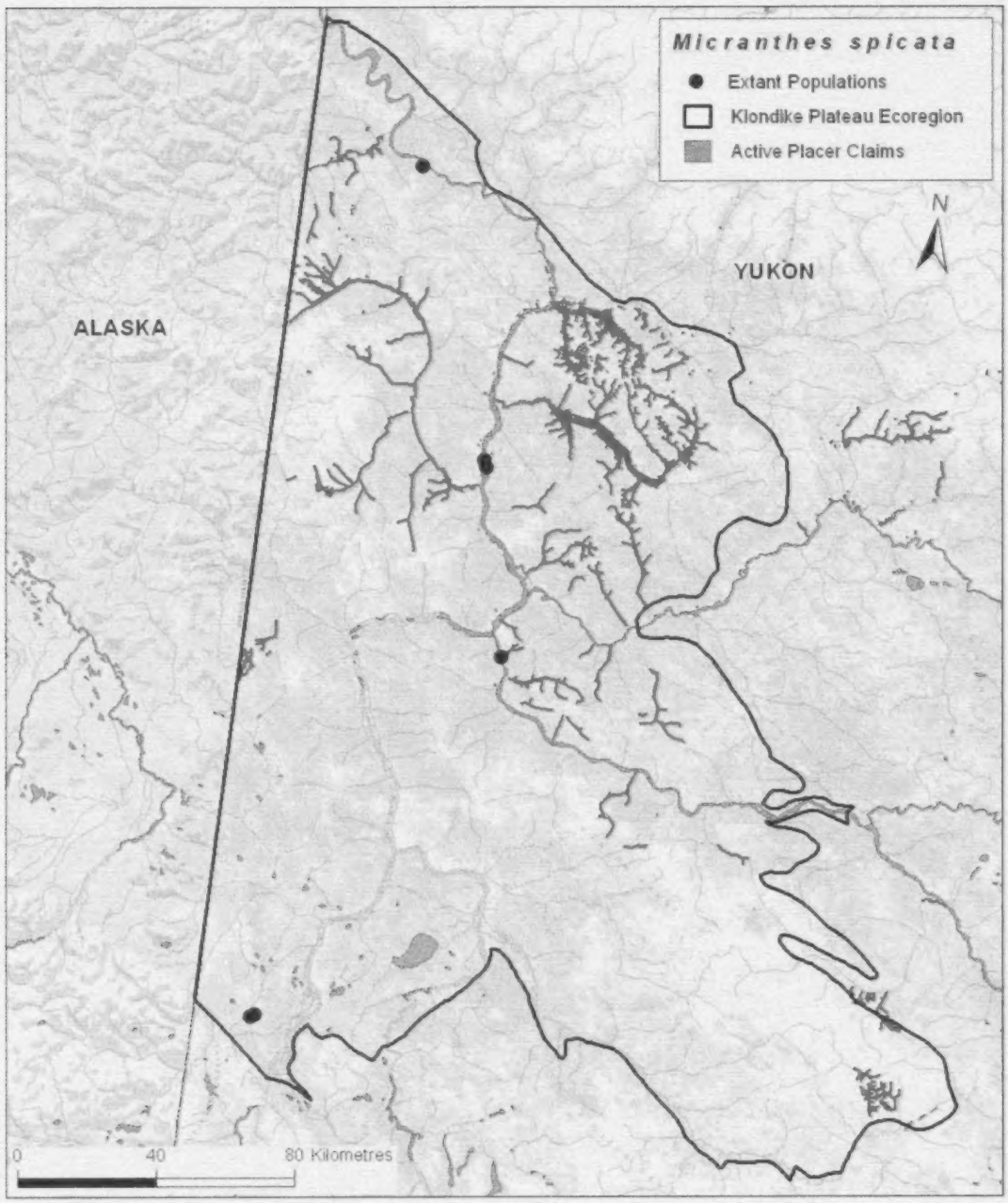

Figure 7. Active placer mining claims (dark grey) in Klondike Plateau Ecoregion (Map: Jenny Wu).

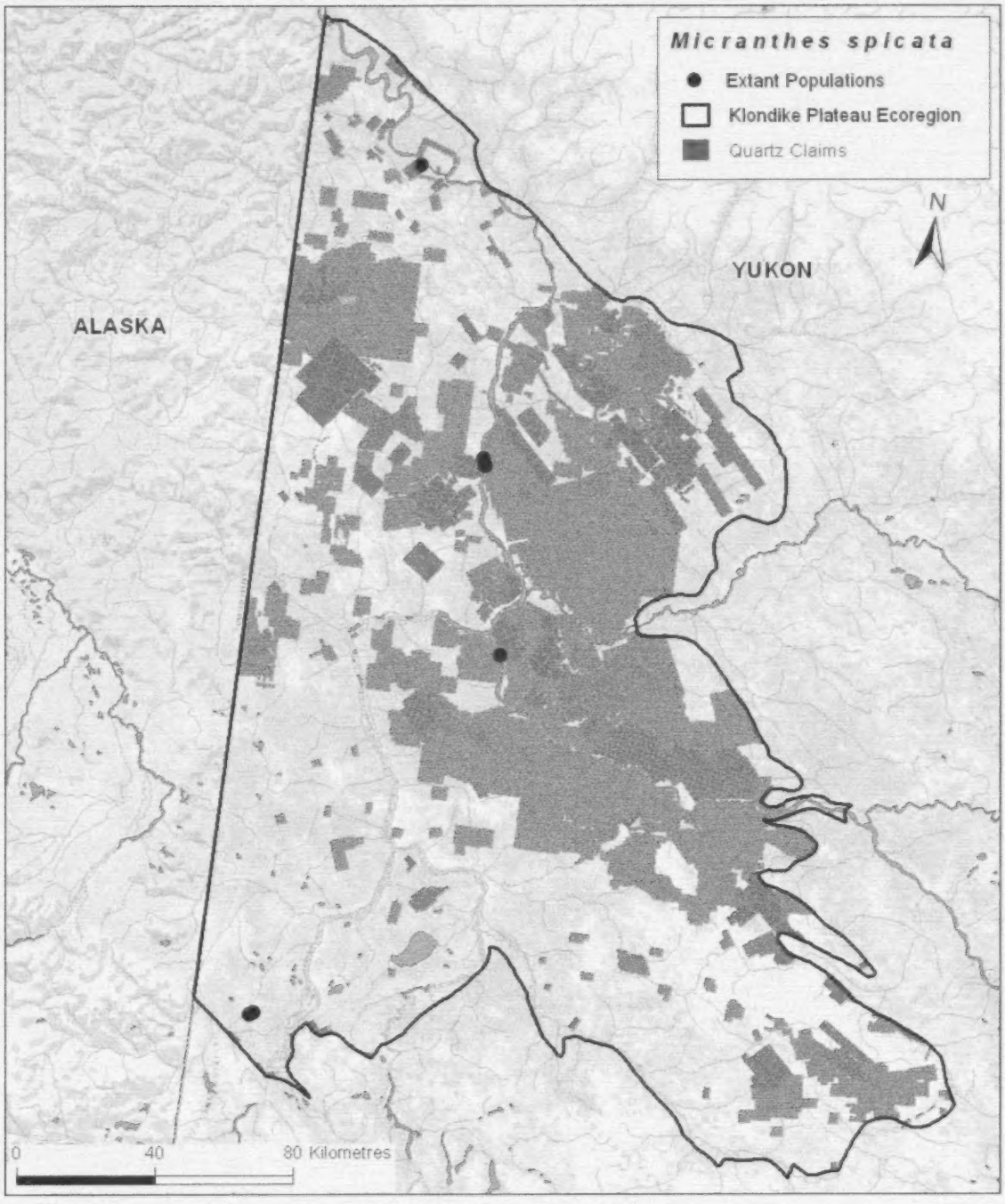

Figure 8. Active quartz mining claims (grey) in Klondike Plateau Ecoregion (Map: Jenny Wu).

The earliest placer mining was carried out using hand tools and improvised machinery. Eventually hydraulic hoses, dredges, and bulldozers came into common use (Gilbert 1989). Such large equipment can rapidly move vast quantities of material, and whole valleys have been dug up, often more than once, as the gravels have been reworked to extract more gold. These practices result in the complete removal of pre-existing vegetation, redirection, damming or infilling of streams, and slope thawing and removal by blasting with hydraulic hoses are the result (Figure 9).

Mesabern Exploration mining on Kate Creek, 2005.

Figure 9. Kate Creek. Photo In: Yukon Placer Mining Industry 2003-2006 (Photo: Yukon Geological Survey).

On creeks where mining has ceased for decades, vegetation has re-established in the valleys to varying degrees. Except for the presence of second-growth forest, landscapes may appear relatively undisturbed except for the occasional decaying cabin, cart track, cut logs, shafts, and so on. Many larger and more recent placer operations are either still being mined, or have been left to revegetate naturally. In some cases, the gravel piles have been recontoured and covered with overburden (excavated material), but the vegetation is still in seral phases of young trees, shrubs, and grasses and forbs, and there is no habitat present considered suitable for Spiked Saxifrage.

While quartz exploration and mining may not affect creeks as extensively as placer mining, potential for riparian habitat degradation exists due to road building, toxic spills, and creation of tailings ponds (Yukon Chamber of Mines 2010).

As of 2011, active placer and quartz mining claims occur on Spiked Saxifrage habitat on Donahue, Dry, and Fourth creeks. Active quartz mining claims occur on Spicata and Snow creeks, but there are no active placer claims. There is evidence of one historical, small placer pit beside the creek's mouth on Spicata Creek, downstream of the plant's occurrence (Cannings pers. comm. 2011). There are no active placer claims or obvious historical mining sign at Snow Creek (Jones 2011) or Sanpete Creek (Bennett 2012).

Natural habitat disturbances that can adversely affect Spiked Saxifrage include flooding, wildfire, and landslides. Flooding may be seasonal or from flash floods following heavy rainfall, which may uproot plants or possibly even eliminate an entire population. While flash floods in the Klondike Plateau Ecoregion are probably not common occurrences (Lipovsky pers. comm. 2012), some stream valleys have been seen to have sustained intensive flooding and creekbed scouring, possibly as a result of heavy summer thunderstorms (Cannings 2010). Wildfires are common in the Klondike Plateau Ecoregion (Smith *et al.* 2004), and can adversely affect microclimate and other critical habitat factors if overstory vegetation along creeks supporting Spiked Saxifrage is burned. Loss of vegetation due to fire on slopes bordering creeks may cause increased thawing of permafrost, which may result in landslides (Lipovsky *et al.* 2006), which in turn may cause flooding, dam or alter creek flow, increase siltation load, or directly destroy populations of Spiked Saxifrage.

Climate change models predict that the annual mean temperature in the west-central Yukon will increase 2.5°C to 3.5°C from 1990 to 2050, and precipitation will increase 20-30% (Werner *et al.* 2009). Not only is Spiked Saxifrage a species associated with very cool microhabitats that may be impacted directly by this climate change, but increased temperatures may be correlated with an increase of extreme weather events and increased incidence of wildfires, both of which are potential threats to the species.

Description of Location

As the threats discussed above could rapidly affect all individuals within each stream system, but as no threats are likely to affect multiple populations, each population is considered to be a location as defined by COSEWIC.

PROTECTION, STATUS, AND RANKS

Legal Protection and Status

Spiked Saxifrage currently has no legal protection in Canada (as of April 2013), and is not listed under the U.S. *Endangered Species Act* and the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES).

The existing known populations of Spiked Saxifrage in Yukon are especially vulnerable to negative impact from mining activities.

Non-Legal Status and Ranks

Spiked Saxifrage has a NatureServe Global rank of G3G4 (Vulnerable to Probably Secure) as of January 21, 2000, with the comment: "Known from more than sixty locations [sites] over a broad area; one site in westernmost Yukon Territory. Additional sites are expected and will likely push this rank to G4" (NatureServe 2011). Its National Rank in the U.S. is N3N4 (Vulnerable to Probably Secure), and in Canada is N2 (Imperilled). Its Subnational Rank in Alaska is S3S4 (Vulnerable to Probably Secure), and in Yukon is S2 (Imperilled).

The National General Status ranks for Canada and Yukon are both 2: "May Be at Risk" (Wild Species 2010).

Habitat Protection and Ownership

All known Canadian Spiked Saxifrage populations are all on Commissioner's (= "Crown") Land under Yukon Territorial jurisdiction, as is most or all the area that has been claimed for placer and quartz mining. While there are restrictions on how operations are conducted on mining claims, these are mainly for the protection of fish habitat under the federal *Fisheries Act*, and there is no legal obligation to protect the habitat or existing populations of Spiked Saxifrage.

Applicants for Yukon placer mining claims must submit an application to the quasi-judicial Yukon Water Board describing their proposed mining operation, and must obtain a water use licence (Yukon Placer Secretariat, November 2010). Each creek is designated as to its suitability for salmonid habitat by the federal Fisheries and Oceans Canada (DFO), and restrictions on placer mining operations and sediment discharge allowable for each level of suitability must be adhered to.

Depending on the designation for a creek, restrictions are placed on allowable discharge of sediment concentrations above background levels, work within 30 metres from the high water mark, construction of new fords, construction of diversion channels, and in-stream works, except where site-specific authorization has been obtained (Yukon Placer Secretariat, November 2010).

Habitat suitability of the lower 500 m of Donahue Creek has been designated as Moderate to High Habitat Suitability (for salmonids) and above 500 m the creek is designated as Low Habitat Suitability. The provisions made to protect the salmon habitat should also afford Spiked Saxifrage habitat some measure of protection. As part of the licensing process, recommendations for protective measures for Spiked Saxifrage at Donahue Creek were made by Environment Canada and the Yukon Department of Environment (Environment Canada 2010; Yukon Environment 2010), but these conditions were not included in the licence ultimately issued by the Yukon Water Board.

Spiked Saxifrage is not known to occur in any park or protected area in Yukon.

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Rhonda Rosie has a life-long interest in vegetation and plant ecology. She began collecting plants, including bryophytes and lichens, in the 1970s in southeast Yukon, and has since collected and studied vegetation in many parts of Yukon for personal interest and as a contractor with Environment Canada, the Yukon Government and the Canadian Parks and Wilderness Society. She has also conducted a number of rare plant surveys as a consultant in Yukon and northern British Columbia.

COLLECTIONS EXAMINED

Pressed specimens from Donahue Creek and Alaska were examined at B.A. Bennett Herbarium (BABY) in Whitehorse, Yukon, and the images and database of specimens held at the University of Alaska Museum of the North (ALA) in Fairbanks, Alaska were viewed using the Arctos online website (University of Alaska Museum of the north 2009).